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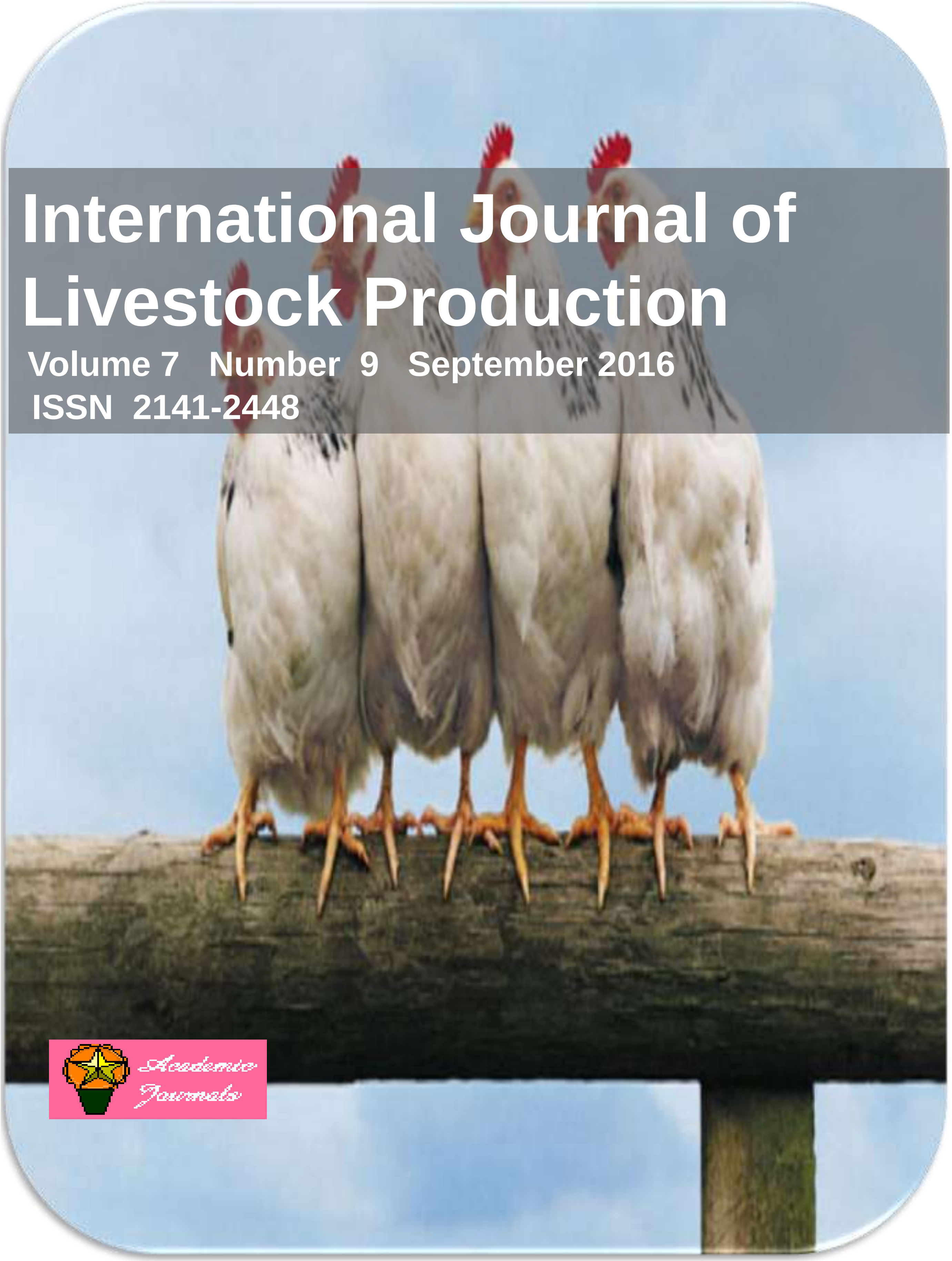

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Full Length Research Paper

Impact of conformation traits on genetic evaluation of length of productive life of holstein cattle

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Length of productive life is an important economic trait in dairy cattle that has shown to have a genetic component and thus, it is subject to improvement through selection. Lifetime records of 13,659 Holstein cows from 72 herds, calving for the first time between January 2000 and December 2014 and their conformation, milk yield (ME 305 d milk) and pedigree information were used to evaluate the relationship of conformation and length of productive life. Length of productive life was adjusted to a maximum of 305 days for each lactation and of these 34% were right censored records. The objective of this study was to investigate the effect of conformation traits on the genetic evaluation of functional length of productive life of Mexican Holstein cattle using survival analysis with a sire-maternal grandsire model. The hazard function was modeled with a baseline function assumed to follow a Weibull distribution, including the fixed covariates of age at first calving and conformation traits (one at a time), time dependent covariates (random effect of herd-year of calving, milk yield level, and lactation phase with changes at 29, 249 and 305 days in each of the first four lactations), and random effects of sire and maternal grandsire. All effects incorporated in the model, before including conformation traits had significant contributions to the likelihood function (P <0.05), and when conformation traits were included, five of them (chest width, teat length, median suspensory ligament, udder texture and udder depth) were statistically significant in order to predict breeding values for length of productive life; therefore the genetic evaluation for length of productive life should include these traits as indirect predictors of longevity. This study strongly recommends the inclusion of conformation traits in the model for genetic improvement of length of productive life of Mexican Holstein cattle.

Key words: Holstein cattle, genetic improvement, conformation traits.

INTRODUCTION

Functional longevity was defined by Ducrocq et al. (1988) as the ability of the cow to avoid culling for reasons other than low performance and it has been reported to be strongly related with length productive life (LPL) measured as the time from the first calving to the death or culling of a cow adjusted by production level (Chirinos et al., 2007). LPL is a trait of increasing importance in cattle breeding programs. In dairy, the economic advantage of LPL lies mainly in retaining productive and healthy cows for as long as possible in the herd and it's important because when herd life is increased, expenses for raising replacement heifers can be decreased (Boettcher et al., 1997); in addition, lifetime milk production can be larger (Van Raden and Wiggans, 1995). LPL of a cow in the herd is influenced by different factors, for example fertility, milk yield, health, management and other reasons of voluntary culling (Ducrocq and Sölkner, 1998a; Weigel et al., 2003).

Many of the current genetic evaluation models for LPL in dairy cattle are based on survival analysis, which allows to combine data on both dead (uncensored/observed LPL) and alive (censored/unobserved LPL) individuals, and enables a proper statistical treatment of censored records and accounts for nonlinear characteristics of LPL data. Survival analysis also allows the estimation of random effects using the covariance structure among observations based on genetic relationships and the calculation of animal culling risks with a mixed model (Ducrocq and Sölkner 1998b; Caraviello et al., 2004). Different traits have been used in order to increase the reliability of the prediction of breeding values for LPL in cattle. For many years, conformation traits have been used as indirect selection criteria for herd life since they can be measured early in productive life (usually during the first lactation) and have moderate genetic correlations with LPL. Different studies have used conformation traits in order to predict LPL (Vukasinovic et al., 2002; Caraviello et al., 2004; Sewalem et al., 2004). In previous studies of dairy cattle in Mexico, longevity was calculated as stability at 48 months or as LPL at the third lactation, using linear mixed models (Valencia et al., 2004) and more recently, survival analysis was used to study LPL including the effect of milk yield level, age at first calving and the time dependent variable of lactation phase (Abadía et al., 2016), but the impact of indirect indicators such as conformation traits has not been evaluated. The Mexican Holstein association scores 24 conformation traits describing udder, feet and legs, rump and body structure systems in a linear scale from 1 to 9, and the explanation of each trait is presented in Appendix A. All traits are being scored according to the standards of the World Holstein Friesian Federation (WHFF, 2005). Considering that LPL is of high economic importance, it presents low heritability and that it is measured late in life, the use of indirect predictors measured early in the LPL of a cow to improve breeding value calculations for this trait is warranted. The objective of this study was to evaluate the effect of conformation traits on the genetic evaluation of LPL of Mexican Holstein Cattle in order to provide a suitable model for the studied population.

MATERIALS AND METHODS

The data set obtained from the Mexican Holstein Association consisted of 37,870 lactation records, corresponding to 13,659 Holstein cows, calving for the first time between January 2000 and December 2014. Data files had corrected ME 305 d milk yield with an average ± STD of 10,050 ± 4,368 kg, age at first calving with an average ± STD of 24.76 ± 2.08 months, censoring indicator (34% of right censored records), LPL adjusted to 305 days per lactation, with accumulated days from the first to the fourth lactation with an average ± STD of 706.90 ± 330.82 days, information of the sire and maternal grandsire and score of 24 conformation traits: height to the withers (HW), stature(ST), size (SI), chest width (CW), body depth (BD), loin strength (LO), rump angle (RA), rump width (RW), foot angle (FA), claw uniformity (UN), heel depth (DH), bone quality (BQ), rear leg side view (RSV), rear leg rear view (RLW), fore udder attachment (FUA), front teat placement **(**FTP), teat length (TL) , median suspensory ligament (MSL), udder texture (TE), rear udder height (RUH), rear udder width (RUW), rear teat placement (RTP), udder depth (UD), and dairy form (DF). All conformation traits were measured in a 1 to 9 discrete scale, and classes with less than 50 observations were added to the immediate superior (classes 1 through 4) or inferior class (classes 6 through 9). Following the methodology described by Ducrocq et al. (1988) the production level was calculated based on the normal distribution of ME Milk yield, animals were classified into 10 levels of milk yield for each lactation, being 1 the lowest production level and 10 the highest. In order to better represent changes in culling risk due to within lactation reproduction and production stages of the cow, the time dependent variable lactation phase was included in the model. Three levels per lactation were considered, the first one from day 1 to 29, the second one from day 30 to 249 and the last one from day 250 to 305. The programs used for editing the data were FORTRAN 5.0 and SAS 9.3.

Model

A Weibull survival model was used for this study. The parameter estimation of the Weibull distribution and the prediction of genetic values were performed using the Survival Kit Software V3.12 (Ducrocq and Sölkner 1998a; Ducrocq 1994), using a sire-maternal grandsire model and including time dependent variables (t). The hazard function h(t) for a particular cow at time t was modeled as follows:

$$h(t) = h0(t)^{*}\, exp\{HY_i(t) + AC_j(t) + PL_k(t) + LP_l(t) + CT_m(t) + S_q + 0.5\, G_r\}$$

where: $h(t)$ is the probability of an animal of being culled at day t after the first calving, $h0(t)$ is baseline hazard function, assumed to follow a Weibull distribution with parameters ρ and λ, $HY_i(t)$ is the effect of herd-year of calving assuming that each herd has its own culling decision process within different calendar years, where *i*=1 to 911, $AC_j(t)$ is the effect of age at first calving in months, where j

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14 classes from 17 to 30 months, $PL_k(t)$ is the effect of production level adjusted in each lactation, where *k*=1 to 10, and $LP_l(t)$ is the effect of lactation phase with changes at the 29, 249 and 305 days in each lactation, where *l*=1 to 12, three phases for each of the first four lactations. $CT_m(t)$ is the score of the conformation traits included one at a time where m=1 to 9, S_q is the random effect of the sire *q*, and G_r is the random effect of the maternal grandsire *r*. Once each of the CT was included in the analysis, those which were statistically significant (p <0.05), were included in a model and in the end, two models were compared:

- Model A) The base model without CT.
- Model B) The base model plus all statistically significant CT.

Heritability

This parameter was estimated in three ways for models A and B. Firstly, the log-linear scale was calculated by Ducrocq and Cassella (1996), using the following formula:

$$h^2_{\log} = \frac{4\,\mathrm{var}(s)}{\frac{\pi^2}{6} + \Psi^{(1)}(\gamma_h) + \mathrm{var}(s)}$$

Where $\mathrm{var}(s)$ is the sire variance, $\frac{\pi^2}{6}$ is the variance of the extreme value distribution, $\Psi^{(1)}(\gamma_h)$ is the trigamma function, which is used to compute the variance of a log-gamma distribution. This parameter was calculated with the Digamma package of the Survival Kit because, the log-linear heritability lacks a biological interpretation and is not closely related with the reliability of genetic evaluations (Ducrocq and Cassella 1996; Ducrocq, 1999), new heritability scales have been developed. Heritability in the original scale was proposed by Ducrocq (1999), and it provides good results for the reliability of genetic evaluations when the parameter ρ is fixed to the value of two. Heritability on the original scale was calculated (Ducrocq 1999):

$$h^2_o = \left[\exp\left\{\frac{1}{\rho}v\right\}\right]^{-2} h^2_{\log}$$

Where *v* is the Euler's constant (−0.5772), *ρ* is the shape parameter of the baseline Weibull distribution, and $h^2_{\log}$ is the heritability in the log-linear scale. This heritability method has been used successful in describing productive life in many populations (Ducrocq, 1999; Larroque and Ducrocq, 2001; Büenguer et al., 2001).

Because the aforementioned estimated h^2_o only included one of the two Weibull distribution parameters, and both parameters are strongly related, different combinations of these parameters may lead to a similar fit of the data. For this reason, Yazdi et al. (2002) developed a formula to estimate the effective heritability, which does not depend on the Weibull parameters and includes the random effects of the gamma distribution. Thus, the effective heritability (h^2_{ef}) was calculated as:

$$h^2_{ef} = \frac{4\,\mathrm{var}(s)}{(\Psi^1\gamma_h + \mathrm{var}(s) + 1)}$$

Where $\mathrm{var}(s)$ is the sire variance and $\psi^l\gamma_h$ is the trigamma function. In dairy populations, this formula has been shown to represent heritability correctly (Büenger et al., 2001; Roxström et al., 2003; Ducrocq, 2005).

Reliability

Sire genetic breeding values reliabilities (*R*) were calculated as a function of sire variance for models A and B as:

$$R = \frac{n_{unc}}{\left(n_{unc} + {}^{1}/_{var(s)}\right)}$$

Where n_{unc} is the number of daughters with observed LPL (uncensored records) and $var(s)$ is the sire variance (Yazdi et al., 2002).

RESULTS AND DISCUSION

From each hazard function, it is possible to semi-parametrically estimate a baseline survivor function (S) and if a Weibull model is adequate, a plot of ln (-ln Ŝ) versus ln (t) should give a straight line with a slope equal to ρ (Kleinbaum, 1996). In this study, the test graph of survival analysis, gave a straight line with a slope close to ρ (1.89) (graph not shown); this results indicates that a Weibull model is proper for the data. Similar ρ values have been estimated in other studies (Dürr et al., 1999; Vollema et al., 2000; Chirinos et al., 2007; Schneider et al., 2005).

All base model effects (AC, PL and LP) were statistically significant (p <0.005), and when CT were tested one at a time, only one body and four udder CT were statistically significant (CW, TL, MSL, TE and UD). Table 1 shows the contribution of variables to the log likelihood function, including all CT scored in Mexico.

Age at first calving (AC)

Cows calving at 21 months of age presented a relative culling risk of approximately 0.7 and it decreased as age at first calving increased until 25 months of age, when cows showed the lowest risk to be culled. Previous studies in the Mexican Holstein population also reported higher culling risks when cows calve early (Abadía et al., 2016), and it could be due to the fact that heifers that calve before 24 months of age, have not reached the appropriate size and weight to calve and this could influence the relative risks. In this study, cows calving after the 26 months showed an increased relative culling risk until the 30 months (Figure 1) possibly because they start their productive life later and reach later parities at older ages. These findings agree with those reported in other populations, where culling risk increased with age (Chirinos et al., 2007, Mészáros et al., 2008).

Table 1. Variable contributions to the likelihood function and Chi square test.

Variable	-2 LOG LIK	CHI^2	Degrees of freedom	Prob > Chi^2
Base model				
Age at first calving	58345	21.39	12	0.004
Production level	56977	1367.80	9	<0.001
Lactation phase	52660	4317.40	11	<0.001
Body structure and capacity				
Stature	115442	11.43	7	0.121
Height to the withers	115442	12.00	8	0.151
Size	115438	15.44	8	0.051
Body depth	115446	7.31	7	0.398
Chest width	**115435**	**19.16**	**8**	**0.014**
Loin strength	115442	11.38	8	0.181
Dairy form	115444	9.18	7	0.240
Rump system				
Rump angle	115452	1.76	8	0.987
Rump width	115442	11.49	7	0.119
Feet and legs system				
Foot angle	115445	8.63	7	0.280
Claw uniformity	115444	9.38	8	0.311
Heel depth	115449	4.18	8	0.899
Bone quality	115451	2.58	7	0.921
Rear leg side view	115444	10.10	7	0.183
Rear leg rear view	115438	15.27	8	0.084
Mammary system				
Udder depth	**115410**	**44.16**	**8**	**<0.001**
Udder texture	**115436**	**17.87**	**7**	**0.013**
Median suspensory ligament	**115434**	**19.84**	**8**	**0.011**
Fore udder attachment	115439	14.28	8	0.075
Front teat placement	115448	5.67	8	0.684
Teat length	**115431**	**22.97**	**8**	**0.003**
Rear udder height	115449	4.36	8	0.823
Rear udder width	115444	10.04	8	0.262
Rear teat placement	115449	5.10	8	0.747

Production level

The influence of production level on relative culling rates is shown in Figure 2. Low producing cows are more likely to be culled than high producing cows, an indication of the influence of voluntary culling for low production. Low producing animals (level 1) have 16.5 times more possibilities to be culled at any given time than animals that have higher production levels (level 7 and 8). Similar results were found in other studies (Vukasinovic et al., 1999; Pasman and Reinhardt, 1999; Terawaki et al., 2006; Weigel et al., 2003). High risks in low production levels have been associated to voluntary culling for milk yield or to health problems, which in turn lower production (Chirinos et al., 2007, Vukasinovic et al., 2001). Animals with extremely high milk production (level 10) have a slightly higher culling risk than those with moderate production (6, 7 and 8). This increase in relative risk was explained previously in this population by Ruiz et al. (1994) and in other populations by Ducrocq et al. (1988)

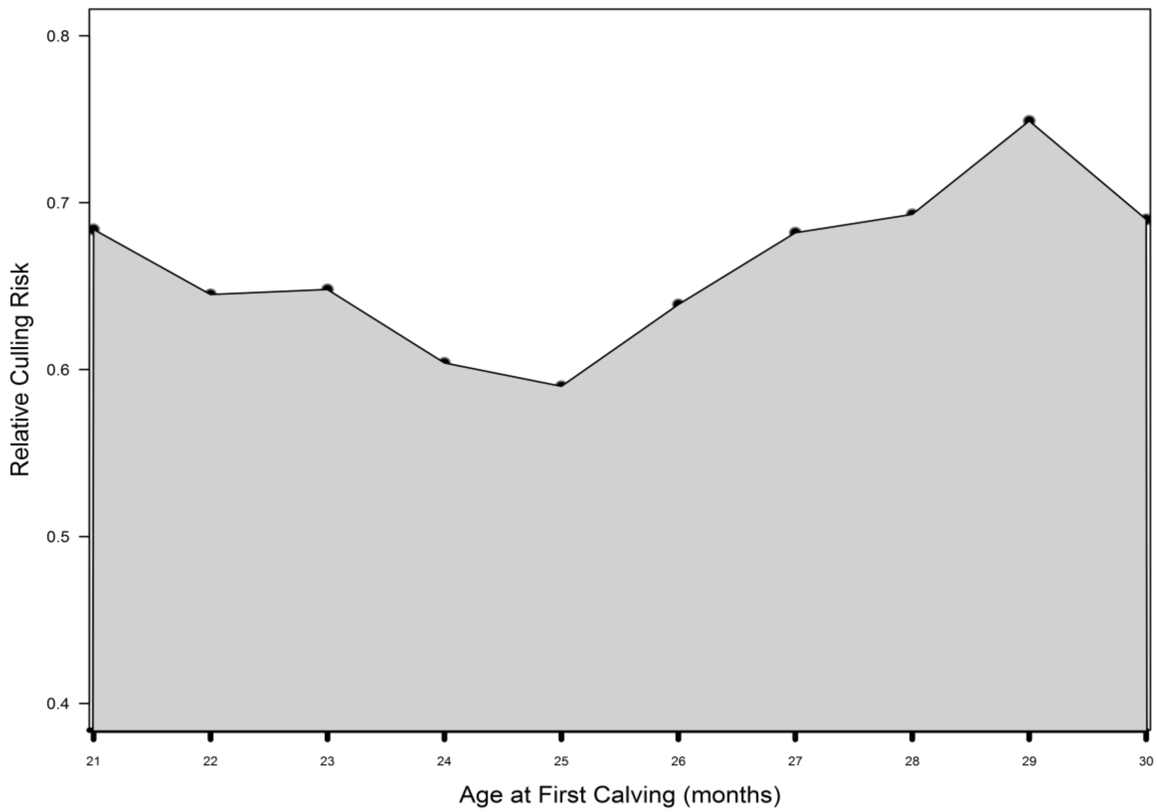

Figure 1. Relative culling risks associated to age at first calving of Holstein cattle in Mexico.

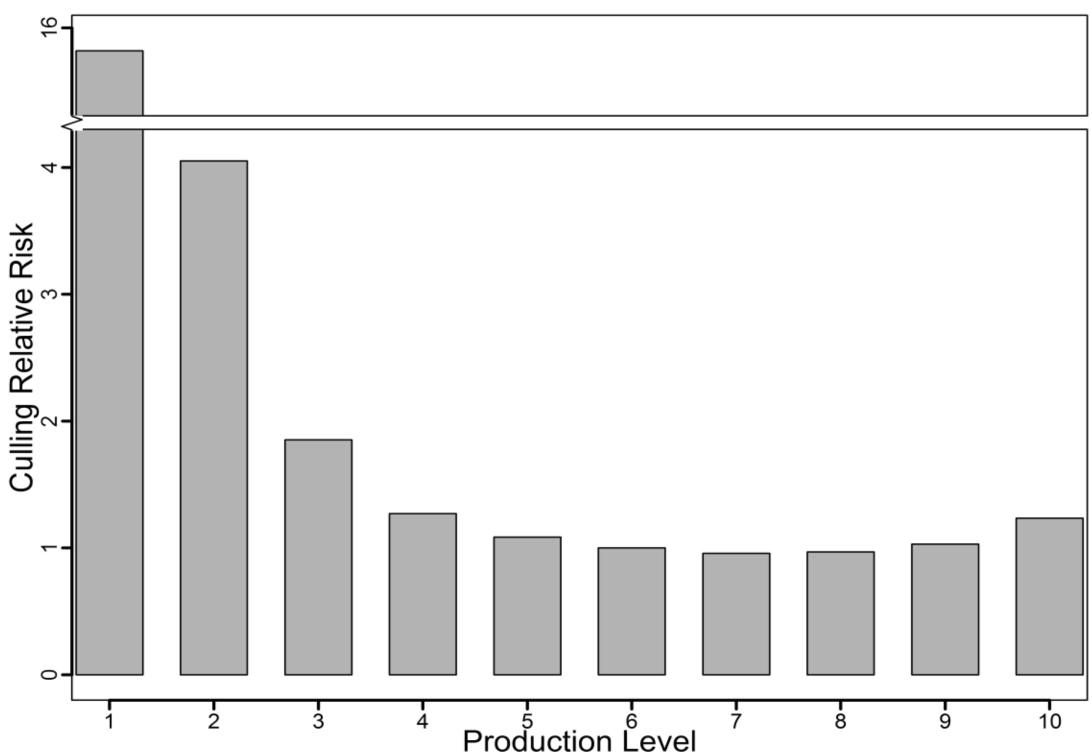

Figure 2. Relative culling risks associated to milk production levels of Holstein cattle in Mexico.

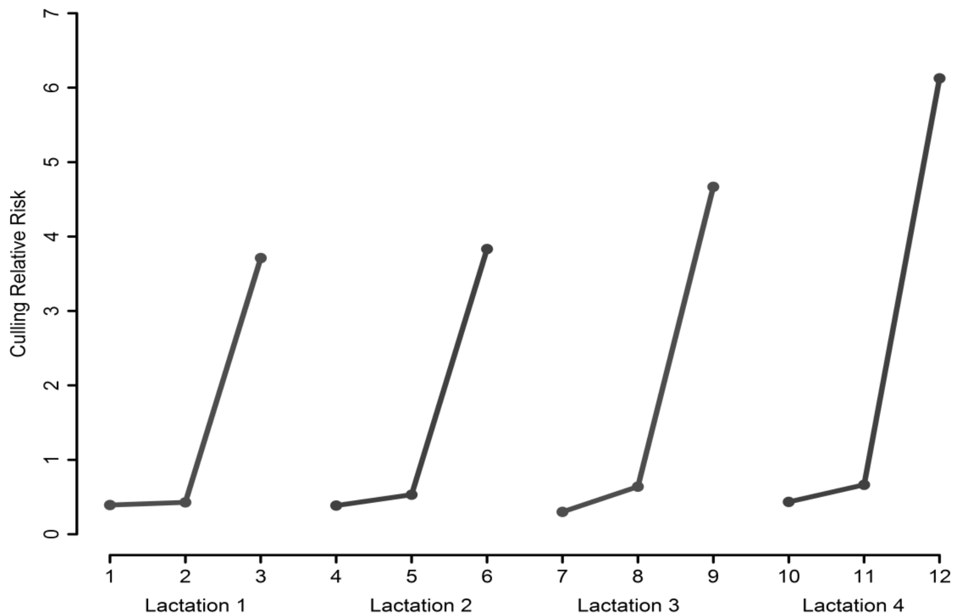

Figure 3. Relative culling risk for lactations (1st, 2nd, 3rd, 4th) and their phases of each one, that include to 0-29, 30-249 and 250-305 days for the phases 1, 2 and 3 respectively in Mexican Holstein population.

and Weigel et al. (2003) who indicated that cows with high production commonly are under stress, particularly in large herds.

Lactation phase (LP)

Figure 3 shows the effect of relative risk in each lactation phase (including 1st, 2nd, 3rd and 4th lactations). Relative culling rates increased from the beginning to the end of each lactation. This trend is in accordance with results presented by Dürr, et al. (1999); Vukasinovic et al. (1999) and Roxtrom et al. (2003) who explained the changes in relative risks as a result of selection pressure changes during the lactation or more intensive culling of non-pregnant cows near the dry period, because cows are culled when they are not pregnant and milk production is finished (Dürr et al., 1999; Vukasinovic et al., 1999 and Terawaki et al., 2006). The relative culling risks across lactations also increased with the cow´s age as reported in other studies in the Mexican dairy cattle Holstein population (Abadía et al., 2016) and in other populations (Dürr *et al.,* 1999; Ducrocq, 1999; Terawaki et al., 2006; Chirinos et al., 2007).

Conformation traits (CT)

Five CT were statistically significant as predictors of LPL. One of them is from the capacity and structure system (CW) and the others from the mammary system (TL, MSL, TE and UD). These findings agree with the results of Dadpasand et al. (2008), which concluded that mammary system traits have a strong relationship with functional longevity. The relative culling risks within scores of CW, TL, MSL, TE and UD traits are presented in Table 2. CW low scores show a high relative risk of culling which decreased as CW scores increased (Table 2, CW). This is probably because cows with low scores, anatomically have narrow chests, which could indicate not enough space for housing vital organs, as the heart and lungs whereas high CW scores indicate a wide chest and enough thoracic capacity. Similar CW culling risk patterns were reported in the Canadian Holstein Population, although, this trait had a low contribution to the likelihood function (<5%; Sewalem et al., 2004) and other populations where other authors have reported moderate correlation between CW and LPL (-0.24) in dairy cattle (Zavadilová et al., 2009). TL presented the lowest culling relative risk in intermediate classes (4, 5 and 6) (Table 2, TL), probably because it is difficult to attach milking units on short teats (scores 1 to 3) and the vacuum will not be optimal, whereas long teats (score 7 to 9) could be in contact with the feet and legs and might catch an infection. Similarly to CW, TL has been reported to have a low contribution to the likelihood function (Sewalem et al., 2004; Morek-Kopeć and Zarnecki, 2012) and its genetic correlation with LPL was still lower (-0.16) than CW (Zavadilová et al., 2009). MSL low scores (≤ 4) did not present a clear relative risk of culling trend, but for the upper five classes (5 to 9) it was observed that animals with high scores, have lower risks to be culled

Table 2. Relative culling rate of the Mexican Holstein cows for the statistically significant ($p < 0.05$) conformation traits.

Score	Conformation traits				
	CW	**TL**	**MSL**	**TE**	**UD**
2	0.55	1.69	-	-	0.49
3	0.52	1.45	0.47	0.68	0.48
4	0.51	1.32	0.45	0.61	0.49
5	0.48	1.39	0.52	0.66	0.46
6	0.46	1.33	0.52	0.62	0.55
7	0.46	1.56	0.49	0.62	0.58
8	0.45	1.45	0.48	0.56	0.75
9	0.45	-	0.44	-	-

CW= Chest width, TL=Teat length, MSL= Median suspensory ligament, TE= Udder texture, UD=Udder depth. Classes with less than 50 observations were not included in the analysis.

(Table 2, MSL) because animals with strong MSL present better supported udders. In other populations, MLS has been reported with medium contributions (~17%) to the likelihood function (Sewalem et al., 2004). TE is a qualitative CT highly associated to longevity in Holstein cattle (Sewalem et al., 2004). In the present study, TE showed that animals with the highest score have lower culling risks than animals with low scores (Table 2, TE). UD is a CT strongly related with true and functional longevity in many populations (Caraviello et al., 2004; Morek-Kopeć and Zarnecki, 2012; Sewalem et al., 2004; Zavadilová et al., 2009). As it was found in Canadian and German Holsteins UD presented a medium optimum in the Mexican Holstein cattle which suggests that cows with the udder floor slightly above the hock have less risk to be culled than cows with udder floors below or above the hock (Sewalem et al., 2004) (Büenger et al., 2001),. These results agree with those reported in Polish Holstein cattle (Morek-Kopeć and Zarnecki, 2012) for true longevity.

Heritability

As mentioned earlier, this parameter was calculated in different ways. LPL heritabilities calculated with model A were 0.06, 0.10 and 0.09 for logarithmic, original and effective scales respectively while for model B the values were 0.08, 0.12 and 0.14, respectively. Previous studies used model A for predicting longevity in the Mexican Holstein population using more life time records (36,507) because animals included in that study were not limited by the presence of conformation traits but only for milk yield. The estimated logarithmic, original and effective scale heritabilities were higher than the ones presented with a similar model (0.08, 0.13 and 0.12, respectively (Abadía et al., 2016). However, results of the current study are in the range of values reported for LPL in other populations (from 0.02 to 0.11 for logarithmic scale from 0.04 to 0.22 for original scale and from 0.03 to 0.19 for equivalent scale (Ducrocq, 1999; Vucasinovic et al., 2001; M'hamdi et al., 2010; Wiebelitz et al., 2014). When the statistically significant CT were included in the model (Model B) for LPL, heritability estimation improved for all scales and the heritability in the effective scale was higher compared to values obtained by Abadía et al. (2016). The heritability values obtained in the current study were also higher values than values obtained in Australian Brown Swiss and Simmental cattle (Sölkner et al., 1999).

Estimated breeding values and reliability

The mean and standard deviation of BV, expressed, as relative risk ratios were 1.06 ± 2.89 and 1.31 ± 4.22 for models A and B respectively. BV distributions for both models are showed in Figure 4. Results suggest that model B, which includes CT has a better fit for LPL, because the included CT increased the proportion of the explained genetic variance and the somewhat larger BV range allows to select the better animals to improve LPL. Additionally, Model B increased the average reliability by 14 percentage points, compared to model A, because reliability depends on the estimated sire variance (Yazdi et al., 2002) which was 0.03 and 0.04 for models A and B, respectively. Results of this study agree with the findings of Vukasinovic et al. (2002), which concluded that the use of CT improves reliability of longevity.

Conclusion

Survival analysis is adequate to calculate length of productive life, to estimate heritability and to predict breeding values in the Mexican Holstein cattle registered population.

The time dependent variables included in the analysis

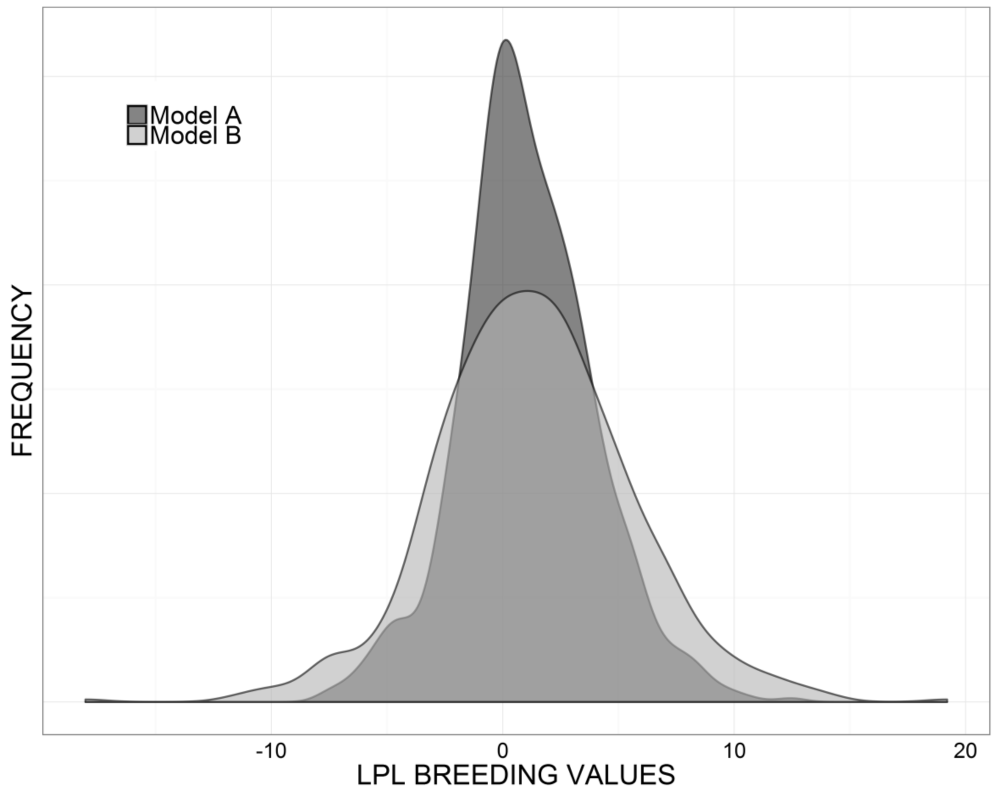

Figure 4. Length of Productive Life (LPL) breeding values distribution for the two models evaluated: Model A) without conformation traits and Model B) including five conformation traits (Chest width, Teat length, Median suspensory ligament, and udder texture and depth.

were good predictors for length of productive life, and five conformation traits were statistically significant in order to improve the length of productive life model. One conformation trait (chest width) was from the structure and capacity system, and the others were related with udder composition (teat length, median suspensory ligament, udder texture and udder depth). The inclusion of these five conformation traits improves the estimation of length of productive life, the prediction of breeding values and its reliability. The only challenge of using conformation traits in the longevity prediction for the Mexican Holstein population is that this information (conformation traits) must be available for all animals included in the analysis, which limits, especially, the number of uncensored data. Nevertheless, the reliability gain and the improvement of breeding value estimation justify the inclusion of the conformation traits. Therefore, inclusion of conformation traits in the length of productive life model of the Mexican Holstein cattle is recommended.

Conflict of interest

The authors have not declared any conflict of interest.

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Abbreviations

LPL, Length of productive life; **HW,** height to the withers; **ST,** stature; **SI,** size; **CW,** chest width; **BD,** body depth; **LO,** loin strength; **RA,** rump angle; **RW,** rump width; **FA,** foot angle; **UN,** claw uniformity; **DH,** heel depth; **BQ,** bone quality; **RSV,** rear leg side view; **RLW,** rear leg rear view; **FUA,** fore udder attachment; **FTP,** front teat placement; **TL,** teat length; **MSL,** median suspensory ligament; **TE,** udder texture; **RUH,** rear udder height; **RUW,** rear udder width; **RTP,** rear teat placement; **UD,** udder depth; **DF,** dairy form.

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APPENDIX A. Conformation traits scored in the Mexican Holstein Population.

System	Trait	Abbreviation	Trait characteristic	
			Low score	High score
Body structure	Height to the withers **	HW	Withers lower than hips	Higher at withers than hips
	Stature**	ST	Short at rump	Tall at rump
	Size **	SI	Small with low body weight	Large and heavy
	Chest width	CW	Narrow	Wide
	Body depth	BD	Shallow	Deep
	Chest width	CW	Narrow	Wide
Rump	Rump angle *	RA	High or low pins	Nearly level
	Rump width	RW	Narrow	Wide
Feet and legs	Loin strength	LO	Weak	Strong
	Foot angle*	FA	Low	Steep
	Claw uniformity	UN	Uniformity	Non uniformity
	Heel depth*	DH	Extremely low or high	Very slight slope to pins
	Bone quality	BQ	Coarse, round boned	Clean-cut, flat boned
	Rear leg side view *	RSV	Very curved or straight	Intermediate hock angle
	Rear leg rear view *	RLW	Strain at hock	Curved at hock
Udder	Fore udder attachment	FUA	Weak	Strong
	Front teat placement*	FTP	Near outside de quarter	Near midline of udder
	Teat length*	TL	Short	Long
	Median suspensory ligament	MSL	Weak	Strong
	Udder texture	TE	Freshly	Pliable
	Rear udder height	RUH	Closer to hocks than to vulva	Close to vulva
	Rear udder width	RUW	Narrow	Wide
	Rear teat placement *	RTP	Wide	Close to midline
	Udder depth*	UD	Udder floor below hock	Udder well above hock
	Dairy form	DF	Freshly coarse throughout, non-angular	Sharp, free from flesh, angular

*Type traits with intermediate optimum (5); ** traits with optimum 7.

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Characterization of low cost village Poultry production in Rwanda

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A study was conducted on 262 indigenous poultry farmers in Rwanda to assess the current status of low cost village poultry production. Majority of the respondents were male (59%) mainly (70.2%) located in urban and Per-urban areas. The majority (56.9%) had primary education and kept the dwarf type (53.5%) followed by the long legged type (26.9%). Stocking birds were mainly sourced from Neighbors (50.8%) and markets (30%). Free scavenging (67.4%) predominated. Disease management lagged as 41.4% farmers never treated birds and 37.2% used indigenous knowledge. Ectoparasitosis (35.2%) and Diarrhea (34.3%) were the main disease conditions cited. Only 15.7% of farmers reported disease outbreak to veterinarians. Clutch size ranged from 5 to 18 with mean of 13 ± 2 and hen maturity age averaged 7± 2.1 month. Farmers reported periodic high morbidity and mortality among poultry flocks with resultant low productivity and profitability. Predators (42%), diseases (23%), lack of credit (20%) were the main challenges stated.

Key words: Indigenous chicken, characterization, management, production, Rwanda.

INTRODUCTION

Rwanda is small, hilly country located in East Africa and like other developing countries, it experiences situations of food insecurity, low household incomes and high prevalence of human and animal diseases. It also faces a challenge of limited availability of animal products; hence, it must increase its animal production base (Economic Development Poverty Reduction Strategy1 2008). In Rwanda, livestock production is a major agricultural activity contributing about 8.8% of the national GDP (FAO, 2012). That is why the government of Rwanda has propounded a deliberate policy to increase meat production through encouragement of pig, poultry and the production of other small animal species (MINAGRI, 2012). The government of Rwanda has set the development vision 2020 (GoR, 2003) and the strategy for poverty reduction and economic development (EDPRS 2, 2013) in which agriculture, especially the livestock sector is one of the pillars of the national

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economy.

Poultry, particularly chicken are the most numerous and widely raised livestock species in the world (FAO, 2012). In Africa, almost every homestead keeps some poultry for mainly home consumption and cash sales (Dwinger and Unger, 2004). In most African countries, the rural chicken population accounts for more than 60% of the total national chicken population *(*Kitalyi, 1998*).* Village poultry production offers many advantages in poverty alleviation programs such as requiring less land, low inputs, and low startup capital (Saleque and Mustafa, 1996). Village poultry also contribute significantly to food security and poverty alleviation in disabled and disadvantaged groups in less favored areas in Africa (Wachira et al., 2010). Furthermore, village poultry are an appropriate means of promoting gender equality as estimated in rural areas of Sub-Saharan Africa, more than 70% of chicken owners were women (Guèye, 2000). Chicken can be reared in small place compared to other type of livestock and this is the situation in Rwanda where average acreage per household is less than a hectare with a high rate of population growth. In Rwanda the village poultry constitutes the majority of the national poultry flock but its role to food security and poverty eradication is often neglected (MINAGRI, 2012).

Poultry industry in Rwanda is characterized by the coexistence of 2 systems: rudimentary village poultry and industrial poultry at its in infancy stage. The 2 systems are facing scarcity of inputs to fully exploit their potential (MINAGRI, 2012). The village chicken sector contributes to the 3000 tons of eggs and 2144 tons of chicken produced annually in Rwanda (FAOSTAT, 2014). Despite this contribution, this sector does not receive attention from many agricultural policy makers (including livestock specialists). Small-scale poultry farming in Rwanda and elsewhere is overlooked by many researchers, development and extension workers as an area of importance in terms of political significance or scientific prestige (Guèye, 2000). Little or no information exists on the profile of indigenous chicken in Rwanda to enable meaning full strategic planning of its development. Therefore a baseline study was conducted to characterize low cost poultry production, identify challenges and propose improvement in this sector.

MATERIALS AND METHODS

The study was carried out in all the 5 provinces of Rwanda (Eastern, Southern, Northern, Western and Kigali city) in the period 2014 to 2015, using a multistage sampling procedure and also based on the poultry population. In each province 50% of districts were selected except Kigali city where all district were selected and in each district 10% of the number of sectors were selected except Kigali city where three sectors /district were selected. This procedure resulted in a total of 48 sectors being included in the study. The report of the third Integrated Household Living Conditions Survey (NISR, EICV III 2012) conducted by Rwanda national institute of statistic indicates the total number of households in Rwanda at 2,492,642, of which 46% kept poultry which are predominately village chicken the poultry keeping households were about 1,146,615.

The ultimate sample size was determined using Slovin's formula, $N' = Nx\ DE / [1+N\ (e)^2]$ (Cochran, 1963), which was applied on the nation chicken population. Accordingly simple size of 210 households from 48 sectors was determined whereas 262 village chicken keeping households were final surveyed in the study. Within the sector village poultry, farmers were randomly selected using the snow ball sampling technique. Data were collected using Pre-tested semi structured questionnaires which were administered by previously trained enumerators in a period of three months, data were entered in SPSS version 16 for descriptive analysis to obtain results (totals, means, ranges, percentages, etc.,) and presented as text, tables and figures.

RESULTS AND DISCUSSION

Social economic characteristic

The study involved 262 respondents of whom 95 (36.6 %) were located in peri-urban, 88 (33.6%) were from urban centers and 79 (29.8%) were from rural areas. These results show that low cost poultry production is relatively well distributed in rural, urban and per-urban areas. This shows that improvement in village poultry production would benefit the livelihoods of rural as well as urban and per-urban dwellers. The average family size was 6 ± 2.2 people which is very close to the national average of 5 members/ household *(*NISR 2012). Overall, 65.2% of the respondents depended only on family labor while 19.3% used family and hired labor and 15.5% only used hired labor. These results show that indigenous poultry farming is not regarded as an economic activity requiring hired labor. The average age of respondents in this study was 35 ± 11.2 years ranging from 17 to 52 years which is in line with the fact that 39% of Rwandese are in their youthful (14 to 35) age range (ECIV 4, 2016). It also suggests that the youth are likely to benefit from any improvements in village poultry production.

With regard to the education level of respondents, the majority (56.9%) had attended primary school, while 24.8% had no formal education, 16% had attained secondary education and only 2.3% had attended tertiary education. The education level of respondents was higher in Kigali city where 21.6% of respondents had attended secondary education level followed by eastern and Northern provinces (13%). None of the respondents from southern and western provinces had attended secondary level of education. The low level of education among the respondents is in accordance to the fact that the majority of Rwandese (78.6%) has primary level of education (NISR, 2012), and therefore improved economic return from low cost poultry farming could go a long way to improve the education levels of the communities.

The results also revealed that house wives (44.5%) were the main caretakers responsible for management of chicken among the surveyed households while 25% were

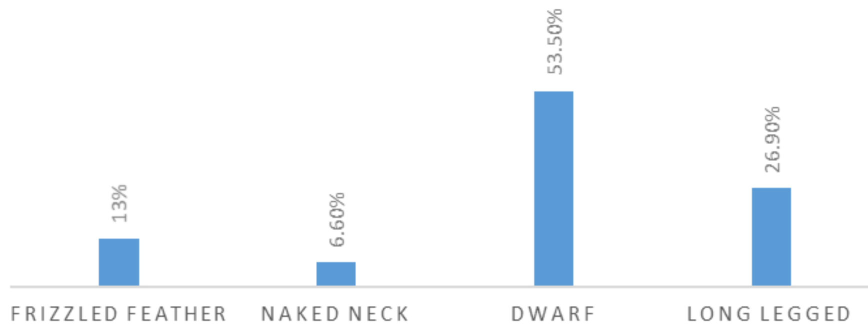

Figure 1. Percentage distribution of respondents keeping different types of indigenous chicken in the study.

reported to be the children, 17.2% husbands and 13.5% declared it was a responsibility of all family members. The family labor input into the rural poultry production system was a plurality but there is more time and labor demand for women than men. Chicken keeping is a domain of women but because of economic priorities, men have changed roles and attitudes towards the enterprise (Okitoi et al., 2007). The findings of this study are also in line with the observations of Bradley (1992) and (Fisseha et al, 2010) that the management of village chicken was highly associated with women for various historical and social factors. Various studies have also come up with the same observations that women and children were generally in charge of village chicken husbandry in developing countries (Riisea, 2004; Kitalyi, 1998; Aboubakar, 2013; Mekonnen and Egziabher 2007.

Flock structure, breeds and breeding

The majority of respondents kept only indigenous chicken (92.4%) and only (7.6%) kept exotics or improved breeds of indigenous chicken. Replacement of flock was done exclusively with their own birds. Traits such as body weight, growth rate, and number of eggs per clutch and tolerance / resistance to diseases were reported to be considered during selection of breeding stock. Among the respondents that kept indigenous chicken, the majority (53.5%) kept the local dwarf breeds followed by the long shank (26.9%) (Figure 1). The dwarf type was widely distributed in all regions especially western (87.4%) followed by Kigali city (62.7%) and Eastern (61.3%). However, the long shank type was most reported (68%) in the Northern Province. The dwarf type are small birds with poor production and growth parameters but may be preferred due to their high prolificacy, adaptability to harsh environmental and poor feeding conditions as well as resistance to diseases (Mahoro et al., 2016).

Indigenous chickens have large morphological variations. Overtimes, morphological variation was selected based on social cultures and beliefs of the community. For example in Ethiopia, Those indigenous birds which have got red or white plumage colors combined with pea shaped comb-types always fetched higher price than their counterparts (Mammo, 2012). The diversified agro-ecologies in country maybe attributing to the presences of diversified phenotypic appearances of local chickens. This may create influences on the market values of chickens. Thus, any breeding and improved production program of the local chickens should therefore, incorporate the production objectives and trait preferences of the society for example in Niger, frizzling and naked neck genes was reported to confer better feed conversion, growth rate, feed efficiency and dressing percentage than the normal feathered chicken (Ajayi, 2010). Such gene pool should be protected from genetic erosion and apply for improvement through traditional selection together along with technologies of genomics (Mammo, 2012).

Therefore, the big gene pool resources in Rwanda should be well characterized and protected from genetic erosion and be used for improvement through traditional selections together with genomic technology. An improving program for indigenous chicken should include both the animal performance and traits preferred by the society

Average flock size

The flock size ranged between 2 to 18 birds per household leading to an average of 8 ± 7.2 and mode range was 5 to 6 birds' .Flock size per households was very small as most households (68.8%) kept less than 5 birds and only (5.8%) kept more than 10 birds. The results of this study differ from those reported in North West Ethiopia (Fisseha et al, 2010) where flock size of indigenous chickens was up to 57 birds. With such small flock size, it is very difficult to raise enough financial income from village chicken production. It is obvious that increasing flock size and its production per unit can go a long way to raise household incomes in rural Rwanda.

Figure 2. Indigenous chicken scavenging for feeds on free range system in Nyanza District (Source: During data collection).

Crossing breeding of local chicken with high performing improved/pure breed has been proven to have positive effects by increasing the overall meat and egg production (Pedersen and Kristensen 2002). However, only, 5.3% of the respondents reported to have adopted this technology. There by the vast number (94.7%) of households reared, local, less productive chickens. New born chicks, eggs and cocks of improved (synthetic genotypes suited for multipurpose production under the Kenyan environment is also available to the farming community). In Rwanda therefore, low cost poultry farmers especially women should be encouraged to rear improved village chicken types such as. Kuroiler, in large flocks. The use of protective chick confinement structures such as brooding baskets will be valuable in ensuring flock growth by reducing chick mortality.

Production systems

Free range with scavenging was only system identified with 47.7% of farmers that had separate night shelter for their chicken. The rests kept their chicken in other places such as the kitchen 1.5% kept the chicken under the granary, while 0.8% kept their poultry under the trees.

Feeding

With regard to feeding of indigenous chicken free scavenging (67.6%) was predominant with only a few 32.4% who supplemented the birds after scavenging. Free scavenging (Figure 2) is a low cost method of feeding but may predispose birds to diseases ,worms, pests and predators (Oakeley, 1998), it can also be associated with uncontrolled breeding, conflicts from straying in the field crops, and low growth rates characteristic of the low input poultry production system (Wang et al., 2009). This kind of production system has low production rates and it is one of the causes for the unsatisfactory performance observed .The chicken in an extensive free ranging system are a function of natural selection and as a result the performance of such chickens remains generally poor due to pronounced broodiness leading to low feed intake, slow growth rates, small body size and low production of meat and eggs(Kitalyi, 1998 and Sonaiya, 2000).

Source of breeding stocks

Most of respondents (50.8%) got their breeding stock (cocks) from neighbors (Table 1) followed by some purchasing from the local market (30%). This can be attributed to the lack of organized indigenous chicken breeding farms in Rwanda.

Farm management and record keeping

Record keeping was rarely practiced as only 7% of respondents kept records. Most farmers reported keeping production records (63%) followed by those who kept income and expenditure (36%). This shows how low input poultry farmer's encounter with difficulties in effective planning, monitoring and evaluating their activities. Among the reasons of not keeping records, about 60% of the respondents mentioned lack of awareness

Table 1. Source of stocking local breeds.

Source of stocking	No. respondents	Percent
Inheritance/ gift	44	16.8
Farmer's neighbours	133	50.8
Government	0	0.0
Non-government organizations (NGOs)	5	1.9
Local market	80	30.5
Total (N)	**262**	**100.0**

Table 2. Different methods of controlling chickens movements**.**

Parameters	No. respondents	Percent
Daily watching	15	7.4
Partial in-shelter confinement	108	52.6
Tethering	82	40
Total	**205**	**100**

(ignorance) as a reason, followed by 36% who cited no value added and the rest (4%) had no specific reason.

Restraint of chickens in cropping season

Partial confinement was reported to be used by 52.6% (Table 2) of respondents for restraining birds against straying. These results are indicative of trend of improvement towards intensification by adapting some form of poultry confinements. Partial in-shelter confinement was a common method of controlling chicken movement Prevention of straying on field crop which was reported by the majority of respondents (64.5%) to be the main reason of controlling chicken movement in the cropping season followed by minimizing losses due to predation (38.5), and also to ensure harmonious neighborhood relations. Low cost poultry farmers in Rwanda should therefore be advised to use local available materials to construct appropriate confinements to reduce poultry straying and predation.

Housing

Various kinds of chicken housing were noticed. As 45.8% of the respondents reported sharing their domestic houses with their chicken, 47.7% reported possession of separate houses. This shows a good trend of evolution in providing shelter to chicken as well as caring for human health. In Ethiopia nearly all (97.6 %) of the respondents did not have a separate house for their chickens (Mekonnen and Egziabher 2007).

Animal health management and husbandry practices

A large number of respondents (98.1%) reported cleaning of poultry shelters as a bio-security measure, 73.2% of them clean the shelters once a day while 22.2% clean twice a week. This shows a good tendency to improved animal health by ensuring animal hygiene and sanitation. The overall management of poultry health was reportedly still very low as 41.4% of the respondents left their sick chicken for self-cure and 37.2% used indigenous knowledge of treatment (traditional, vein piercing and defeathering). Modern approaches to poultry disease management were still very low as only 15.7% of respondents reportedly to consult veterinarians in case of outbreaks of poultry diseases. This may explain the often very high morbidity and mortality among indigenous poultry flocks and the resultants low productivity and profitability (Msoffe et al., 2010).

The use of poultry and their products

The results on use of poultry and their products were indicative of a reasonable shift from subsistence to commercial production as 75.2% of the respondents reported selling their chickens and eggs nearby or at local market to raise household income or resolve other family problems. This result is in agreement with other researchers who while working in Ethiopia concluded that selling of live birds for income generation was the primary goal of keeping low input poultry in developing countries (Sonaiya, 2006).

Production parameters

The production parameters derived from the study population were characteristic of a system with very low production and productivity. The average flock size was 8 birds per household, clutch size varied between 5 to 18 eggs with an average of 12 eggs per cycle. Chick's mortality was very high with average chicks surviving/ hen/ batch to be four and growth rate was also reportedly low as age at maturity was cited to be 7 months for female birds and 6 for cockerels. This was similar to the situation in southern Ethiopia where average clutch size was 14 eggs and duration to fist egg was 6 months (Mekonnen and Egziabher 2007). In similar study in Bure district, North West Ethiopia, the average age of cockerels at first mating and pullets at first egg were 24.6 weeks and 27.5 weeks, respectively. The average number of eggs laid/clutch was 16 (ranged 8 to 28) and the number of total clutch periods/hen/year was 4 (ranged 2 to 6). The annual egg production performance of local hens, under farmer's management condition, was 60 eggs/hen (ranged 24 to 112). (Moges et al., 2010)

Reported challenges

Predators were reported (32%) to be the main challenge followed by ectoparasite and enteric diseases (23%). These finding is similar to that of (Halima et al., 2007*)* working in North-western Ethiopia also reported. It is noteworthy that the majority of respondents (76.1%) reported poultry confinement as the method used to prevent predation. Others use trap nets (11.2%) and scarecrows (4.2%) while others do nothing. Other challenges included poor access to credit (20%), lack of veterinary services (14%) and quality breeding materials (11%).

In southern Ethiopia, critical constraints of the smallholder poultry production in the study area were partly due to the prevailing poor management practices, in particular predation, lack of proper health care, and poor housing (Mekonnen and Egziabher 2007). Efforts of low cost poultry farmers in Rwanda should therefore be consolidated into cooperatives for easy access to services (technologies, credit, inputs etc.) thereby easing most of the prevailing challenges. Special attention should be given to sourcing of genuine improved genotypes through farmer cooperatives.

Conclusion

The indigenous chicken of various types were the most common (53.5%) and all the bird types had low production parameters: an average clutch size of 12 eggs, 3 cycles per year and late maturity age. Designated houses for night poultry confinement were still rare (48%). Birds were not confined during the day, and free scavenging (67.4%) prevailed. Ecto parasite and diarrhea were common. A larger number of farmers 41% did not treat sick birds whereas 37% of respondents used traditional treatments, leading to high mortality and reduced productivity.

It is therefore evident that low cost poultry production in Rwanda is characterized by small flocks, a low levels of production ,lack of breeding schemes, lack of genetically selected breeding birds, lack of treatment, lack of facilities and information among others. With the reported small flock sizes it is difficulty for local poultry production to make adequate income. Housewives were the major responsible for poultry production. Based on all the findings, low cost poultry production in Rwanda still lacks attention to achieve their potential in helping poor families with an income and food source."

Conflict of Interests

The author has not declared any conflict of interests.

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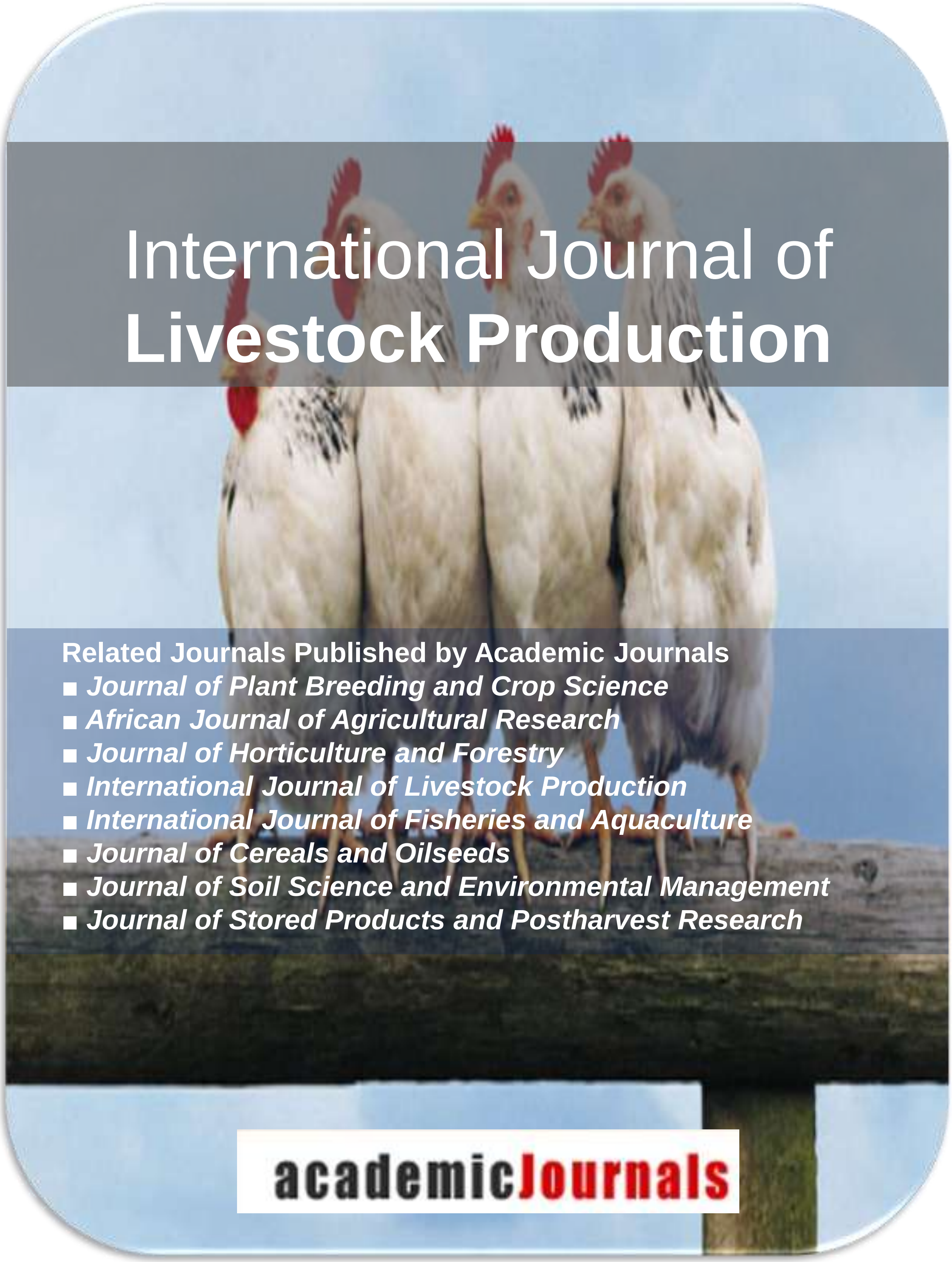

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